DURABILITY OF ULTRA HIGH PERFORMANCE CONCRETE INCORPORATING PALM OIL CLINKER AS AGGREGATE REPLACEMENT

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Kemajuan dalam industri pembinaan telah meningkatkan penggunaan konkrit. Hasilnya, permintaan untuk agregat kasar juga meningkat. Peningkatan dalam permintaan agregat kasar telah menyebabkan kepupusan dalam sumber mentah semulajadi seterusnya menyumbang kepada pencemaran. Satu alternatif kepada batuan kerikil sangat diperlukan untuk menyelesaikan masalah ini dan klinker minyak kelapa sawit adalah bahan yang sesuai untuk menggantikan batuan kerikil oleh kerana persamaan sifat bahan dengan agregat semula jadi. Ketahanan konkrit yang mengandungi klinker minyak kelapa sawit ditelusuri dalam kajian ini dan dibandingkan dengan ketahanan konkrit konvensional. Tambahan pula, kesesuaian klinker minyak kelapa sawit di dalam konkrit telah dikaji untuk mampu mengurangkan kebergantungan kepada agregat semula jadi di dalam penghasilan konkrit. Konkrit yang mengandungi klinker minyak kelapa sawit ialah sejenis konkrit yang mana mempunyai agregat semula jadi yang diganti dengan klinker minyak kelapa sawit sebanyak 5%, 10% dan 15% dan menghasilkan satu bancuhan konkrit yang baru. Ketahanan kedua-dua jenis konkrit ditentukan dalam tiga ujian ketahanan. Ujian ketahanan untuk kedua-dua jenis konkrit adalah ujian kuantiti, ujian penyerapan air dan ujian penembusan air. Saiz sampel yang digunakan dalam uji kaji ialah 100 mm x 100 mm x 100 mm. Kesemua sampel kiub telah diletakkan di dalam air untuk 7, 28 dan 60 hari sehingga kekuatan maksimum dicapai. Perubahan berat dan keliangan konkrit telah ditentukan dan ketahanan telah dibincangkan dan dibandingkan. Keputusan uji kaji menunjukkan bahawa konkrit konevensional adalah mempunya ketahanan yang lebih berbanding dengan konkrit yang mengandungi klinker minyak kelapa sawit. Dalam ujian penyerapan air, konkrit konvensional mencapai nilai penyerapan air sebanyak 0.651 sementara konkrit yang mengandungi klinker minyak kelapa sawit mencapai nilai sebanyak 0.662. Dalam ujian penembusan air, lebih banyak air yang menembusi ke dalam konkrit dengan klinker minyak kelapa sawit berbanding konkrit konvensional. Ketahanan konkrit dikaitkan dengan keliangan dan kebolehtelapan konkrit. Daripada kajian, ini menujukkan bahawa konkrit konvensional mempunyai ketahanan yang baik berbanding konkrit dengan klinker minyak kelapa sawit. Walaubagimanapun, ketahanan konkrit minyak kelapa sawit masih boleh diterima pakai dan penggunaan sebahagian klinker minyak kelapa sawit sebagai pengganti agregat kasar mampu mengurangkan kebergantungan kepada bahan semula jadi di dalam industri konkrit.

ABSTRACT

The advancement in the construction industry has promoted the utilization of concrete. Hence, the market for the coarse aggregate is also increased. The increase in demand on the coarse aggregate has led to the depletion of these natural resources thus contributed to the pollution. An alternative to the gravel is required to solve the problem and palm oil clinker is the appropriate substances that can replace the gravel because of its similar properties to the natural aggregate. The durability of the concrete incorporating palm oil clinker was studied in this research and being compared to the durability of the conventional concrete. Furthermore, the suitability of palm oil clinker in the concrete was studied to reduce the reliance of the natural aggregate in the production of concrete. Palm oil clinker concrete is a type of concrete where of the coarse aggregate was replaced by 5%, 10% and 15% of palm oil clinker and produce a new concrete mix. The durability of both of concretes was determined in three durability tests. The tests for durability of the concrete are water absorption test, sorptivity test and water penetration test. The size sample used for the test is 100x100x100 mm. All the cubes samples were cured in the water for 7, 28 and 60 days until it reach the maximum strength. The change in mass and the porosity of the concrete was determined and the durability properties was discussed and being compared. The result shows that the conventional concrete is more durable compared to the concrete incorporate palm oil clinker. In the sorptivity test, conventional concrete has sorptivity value about 0.651 while palm oil clinker concrete was about 0.662. In term of water penetration, more water was penetrated in palm oil concrete compared to the conventional concrete. The durability of the concrete was related to the porosity and permeability of the concrete. From the result, it shows that concrete with have higher porosity is more permeable to the solution and cause matrix destruction. That described that the conventional concrete has better durability than palm oil clinker concrete. Nevertheless, the durability of palm oil clinker is still acceptable and the partial used of the palm oil clinker as coarse aggregate replacement can reduce the dependency of natural resources in the concrete industry.

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LIST OF SYMBOLS

mm	Millimetre
%	Percentage
kg/m^3	Kilogram per cubic metre
µm	Micrometre
N/mm^2	Newton per millimetres square
±	Plus-minus
ºC	Degree Celsius
$mm/min^{0.5}$	Milimeter per $minutes^{0.5}$
g	Gram

LIST OF ABBREVIATIONS

UHPC	Ultra High Performance Concrete
POC	Palm Oil Clinker
OPS	Oil Palm Shell
POFA	Palm Oil Fuel Ash
ASTM	American Society for Testing and Materials
BS	British Standard
HPC	High Performance Concrete
SiO2	Silicon Dioxide
Al_2O_3	Aluminium Oxide
Fe_2O_3	Iron (III) Oxide
OPSC	Oil Palm Shell Concrete
BCCFA	Bone China Ceramic Fine Aggregate
OPC	Ordinary Portland cement
NSC	Normal Strength Concrete
CSH	Calcium Silicate Hydrate
min	minutes

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Construction industry is now becoming a phenomenal in world. Every country in the world is competing to show who have the best development. The development in the property and buildings industries has a direct relationship with the rapid growth of construction industries. Urbanisation elementary has boosted the rate of population of people. Hence, construction industry growth is anticipated to rise in 10 years future ahead especially in infrastructures and housing segment.

As the construction industry is undergoing evolution, same goes to concrete technology which are known as ultra-high performance concrete (UHPC). UHPC has been characterized by a very low water- binder ratio, a very high cement content which is the amount is more than twice the amount in ordinary concrete and uniformly distribution of the reinforcing components (Liu, El-tawil, Hansen, & Wang, 2018). UHPC have been widely used in construction of bridges and highways (Li, Tan, & Yang, 2018). The material is likely to make a considerable contribution to handle the challenges in high capacity, mechanical strength, durability, ductility and energy absorption capacity (Zhou & Qiao, 2018).. Despite of every pro, the thought that the effect of this industrial growth will harm the environmental and changes in climate. For instance, the production of cement which is a vital raw material in construction will causes extreme production of carbon dioxide in environment which will cause increment in in temperature which known as greenhouse effect. Due to accumulation of construction needed, huge amount of concrete is needed. Cement has high demand rate in market. Due to this, research have been conducted in order to find suitable material

that can replace the cement by investigating the effectiveness and efficiency of waste materials (E. Aprianti, P. Shafigh, S. Bahri et al.,2015). For instance, according to research by (S, 2016) , slag have been used to replace the cement in the research. Fly ash, palm oil fuel ash and silica fume are among popular raw material that can be used to replace the original cement because they are waste material that can be processed as cement replacement and they emit low amount of carbon dioxide.

As a reminder, cement is not the only material used in construction. An aggregate also is important raw material used in concrete. Amount of aggregate is quite worrying because it is getting depleted day by day as the use of aggregate is not only applicable to construction industry. Aggregate is non-renewable natural resources because it is been produced by the earth and sadly about to depleted in time. Aggregate that been used in construction industry is supplied from quarry. As the aggregate source is getting depleted, an alternative to this source is introduced.

Palm oil clinker (POC) is an alternative to the course aggregate due to suitability to replace the aggregate and can improve better in concrete mix. Replacement of POC in concrete mix produced a lightweight concrete. POC is waste material that been produced after the palm oil shell been processed. Uses of by-product from palm oil industry such as POC and oil palm shell (OPS) should be appraise as lightweight aggregates due to the limitation of natural waste and the output should be more sustainable (R. Ahmmad, M. Zamin, U. Alengaram et al., 2016). They carried out research on application of POC aggregate and POC powder to replace the coarse aggregate and filler materials to produce lightweight concrete.

POC is an option to the coarse aggregate due to its similarity physical characters which is hardened stone. POC comes in solid form and is a lightweight material with sharp and broken edges, and flaky and have irregular shape (F. Abutaha, H. Razak, H. Ibrahim et al., 2018). The cost of getting this waste very low since it has low commercial value in market. Hence, by using this by-product can reduce the cost of construction by reducing the cost of getting the raw material since the product is a waste product and we can get this material for free from the palm oil factory.

1.2 PROBLEM STATEMENT

Consciousness of environmental issues of waste disposal and high demand toward construction material like stone and pebbles. The argument that construction industry need to discover and acquire material replacement especially from recycle material or waste material. Exploitation towards the solid waste is very hassle. Using a waste material in construction industry is one of the approach to ensure that waste material have been manage correctly and may reduce the area of landfill for waste material disposal. Palm oil clinker (POC) is one of the waste materials that are available in Malaysia. Malaysia is the second largest producing country in producing palm oil in the world. There are about 200 palm oil mills that are operated in Malaysia and in a year they can produce about 100 tonnes of palm oil fuel ash (POFA) (Kabir et al., 2017a). Due to this enormous industry that contribute to the waste, Malaysia is responsible to handle the huge amount of the solid wastes such as OPS, POC, empty fruit bunches and palm oil mill effluent (Huda, Zamin, Jumat, & Islam, 2016). With amount of palm oil industry are expected to increase in the future, using POC as an alternative construction material is a right step to preserve the environment.

Reducing the number of natural aggregate used is also one of the ways to preserve the environment. Overuse of aggregate can give a bad impact to the environment. Thus, study on uses POC as an alternative coarse aggregate in construction industry with a view of effective utilization of the resources and environmental protection is essential. In order to examine the effectiveness of POC as a partial coarse aggregate replacement in UHPC and it applicability, research is conducted in order to solve the problems that may in future.

UHPC with normal aggregate may easily attack due to weak durability of concrete. The replacement of waste material into UHPC is fortified in order to improve the durability of the UHPC itself. POC is a type of coarse aggregate that is hard as aggregate but with better aspect which is light compared to the natural aggregates. Furthermore, POC have the potential to gain better durability compared when the normal aggregate is used to be prove in this matter.

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